Monetary policy and US housing expansions: the case of time-varying supply elasticities
- online appendix -

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A. Prior distributions

The Bayesian approach to estimate the TVP-VAR model requires choices for the prior distributions of the unobserved coefficients and the innovation covariance matrices of the observation and the transition equation. We apply natural conjugate priors that lead to analytical results for the conditional posterior distributions from which samples can be readily obtained. Since posterior results of TVP-VAR models can be sensitive to prior choices, we follow Primiceri (2005) and calibrate the prior hyperparameters based on the OLS estimates from a constant VAR specification over the training sample 1975M5–1990M12. Specifically, the prior distributions are

$$C_0 \sim \mathcal{N}\left(\widehat{C}_{OLS}, 4 \cdot Cov(\widehat{C}_{OLS})\right),$$
$$\Sigma \sim \mathcal{IW}\left(I_N, N+1\right),$$
$$\mathcal{Q} \sim \mathcal{IW}\left(\kappa_{\mathcal{Q}}^2 \cdot T_0 \cdot Cov(\widehat{C}_{OLS}), T_0\right),$$

where $T_0 = 188$ is the size of the training sample and $\kappa_{\mathcal{Q}}$ measures the prior belief about time variation in the coefficients. We follow Primiceri (2005) and set $\kappa_{\mathcal{Q}} = 0.01$. Since the monetary policy surprises are only available since 1988M11, z_t is set to zero for the remaining part of the training sample.

B. Details on the exogenous variable approach

Our TVP-VAR(X) model adopts the exogenous variable approach from Paul (2020). By including pre-identified policy surprises as an exogenous variable in the VAR framework, we obtain the impulse responses of interest in a straightforward way. Assuming that z_t is a noisy measure of the monetary policy shock, the contemporaneous impulse response of variable i relative to an exogenous one-unit increase in the policy rate R is given by $r_{i,t} = \bar{A}_{i,t}/\bar{A}_{R,t}$. The subsequent relative impulse responses can be obtained by tracing the initial impulse in R through the dynamics of Equation (1) in the paper. The exogenous variable approach consistently estimates the contemporaneous relative responses and, assuming that z_t is uncorrelated with the remaining regressors, the subsequent relative responses. To guarantee orthogonality of z_t, we 'clean' the surprise series by regressing it on the remaining right-hand side variables of Equation 1 and using the residuals from this regression as z_t. Similarly to Paul (2020), we do not find this step to affect the results significantly. Finally, Paul (2020) shows that the contemporaneous relative impulse responses are always identical to those obtained from the related external instrument approach of Stock and Watson (2012).

C. Data

Baseline model:

Policy rate: Shadow rate that accounts for the Zero Lower Bound on nominal interest rates taken from Wu and Xia (2016).

Inflation: Consumer Price Index for all urban consumers: all items (FRED code: CPIAUCSL).

House prices: S&P/Case-Shiller U.S. National Home Price Index (FRED code: CSUSHPISA). Data before 1987 is available on Robert Shiller's website.

Building permits: New private housing units authorized (FRED code: PERMIT).

GDP: Real GDP from Macroeconomic Advisers by IHS Markit.

Bank credit: Bank credit from all commercial banks (FRED code: LOANINV).

GZ spread: Corporate credit spreads, updated series based on Gilchrist and

Zakrajšek (2012).

Robustness checks:

Policy rate: Federal funds rate (FRED code: FEDFUNDS), and the two-year Treasury rate (FRED code: GS2).

Industrial production: Real industrial production (FRED code: INDPRO).

Non-farm payroll employment: Number of workers in the economy excluding proprietors, private household employees, unpaid volunteers, farm employees, and the unincorporated self-employed (FRED code: PAYEMS).

Unemployment rate: Number of unemployed as a percentage of the labor force (FRED code: UNRATE).

Housing starts: New privately owned housing units started (FRED code: HOUST).

Alternative monetary policy surprises: Jarociński and Karadi (2020) poor man's sign restrictions, available over 1988M11–2016M12; Bu et al. (2019) monetary policy surprise series, available over 1994M2–2017M12.

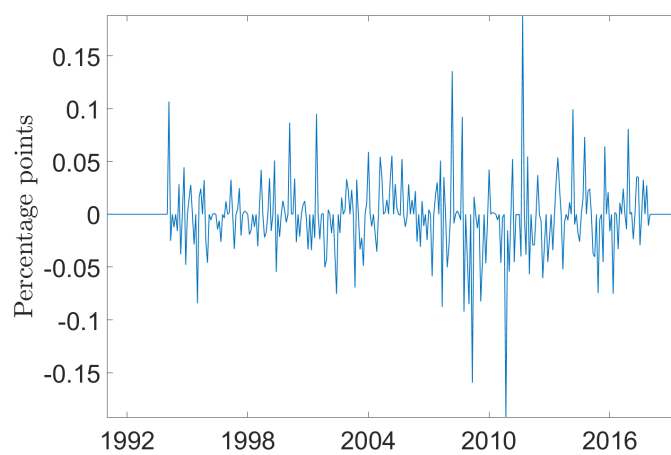Figure 1: (Transformed) Data series of baseline model
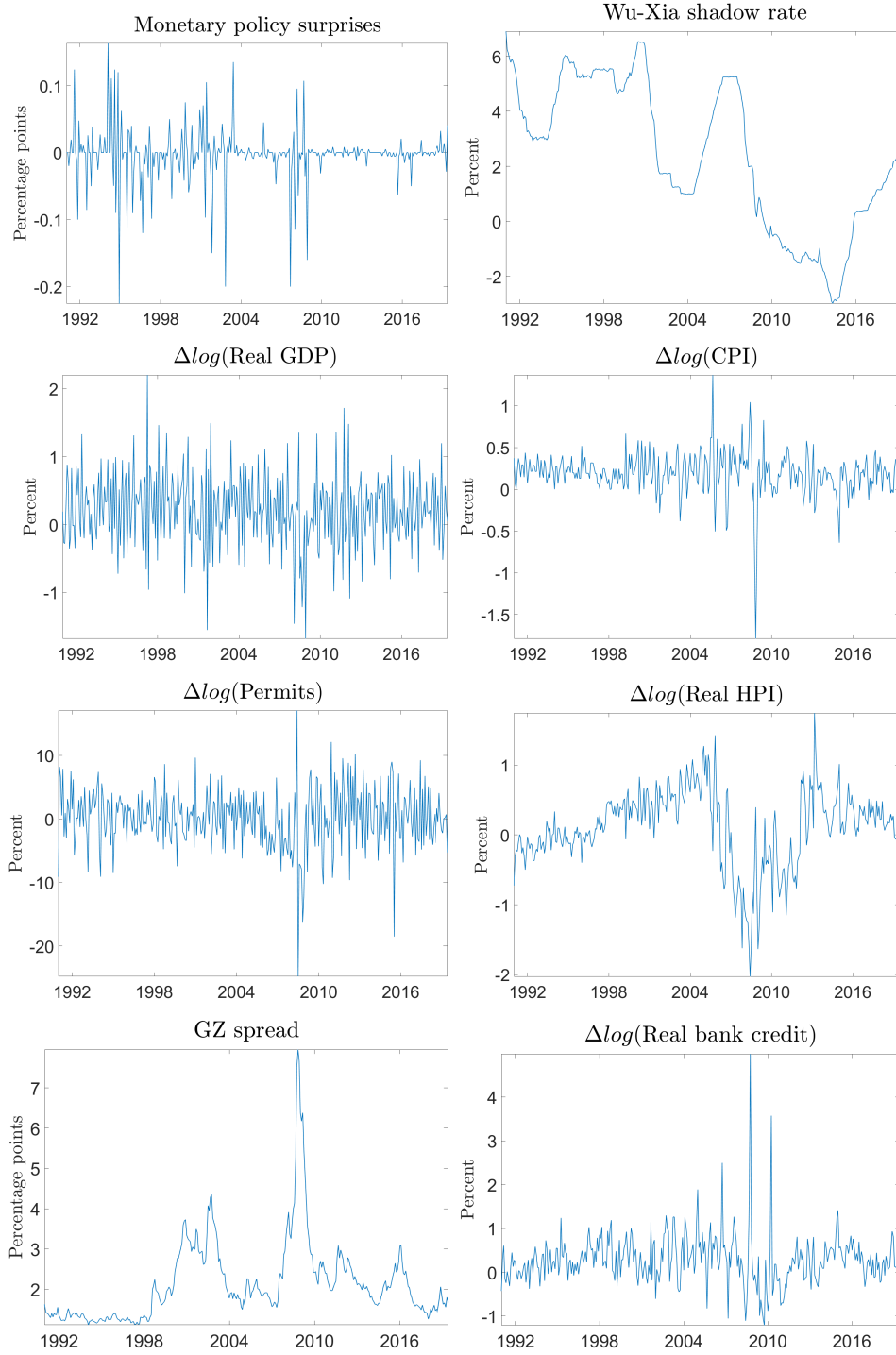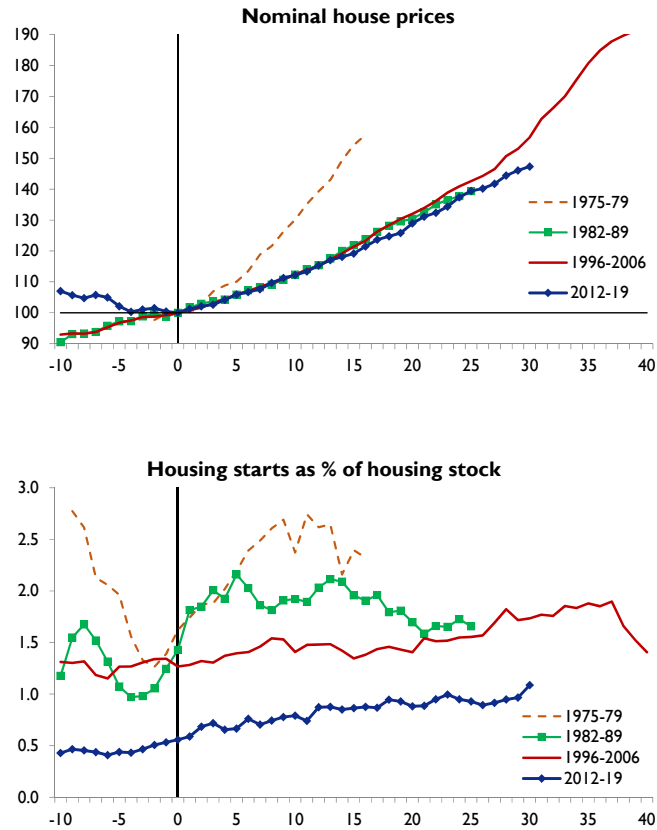
Figure 2: Alternative monetary policy surprise series
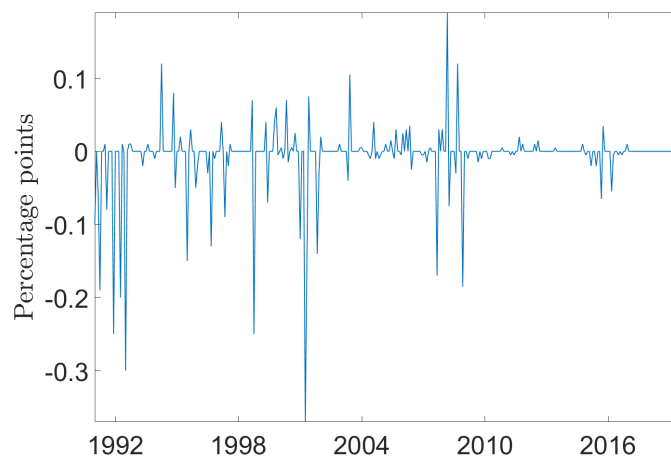
(a) Jarociński and Karadi (2020) poor man's sign restrictions

(b) Bu et al. (2019) monetary policy surprise series

D. Additional figures

Figure 3: Housing expansions since 1975

Nominal house prices

Housing starts as % of housing stock

Sources: Bureau of Economic Analysis, Census Bureau, Federal Housing Finance Agency, and authors' calculations.

Notes: Real GDP and real house prices scaled to 100 at the beginning of each housing expansion. Building permits in % of the housing stock at the beginning of each expansion. The vertical line at zero is the starting point of each expansion; x-axis is in quarters.

E. Additional robustness checks

1. Alternative measure of housing supply: housing starts

Figure 4: Time-varying impulse response functions

Real house prices

Housing starts
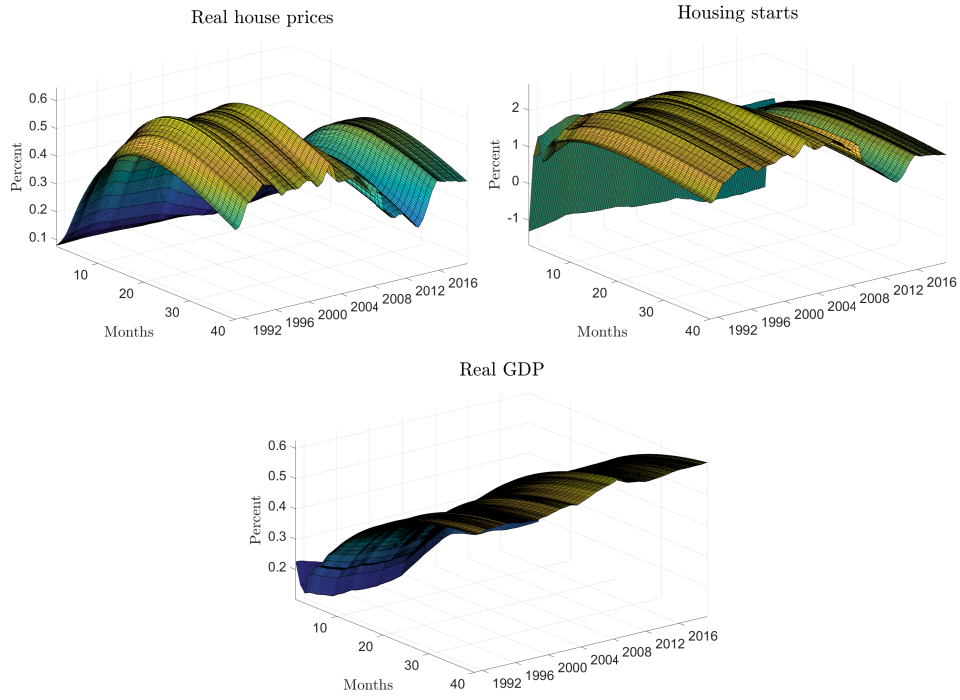
Real GDP

Notes: Cumulative mean time-varying responses of real house prices, housing starts, and real GDP to an expansionary monetary policy shock that decreases the policy rate by 25 bp in 1991M1.

Figure 5: Relative impulse response functions
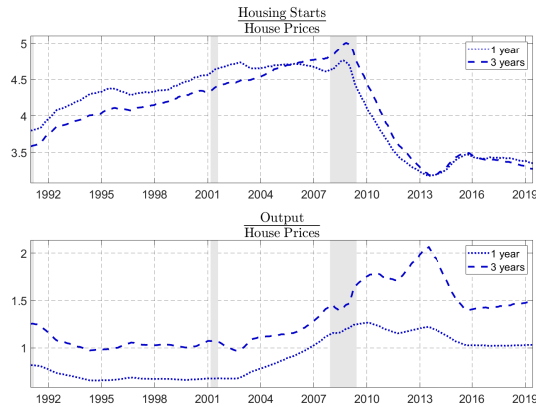
Notes: Cumulative mean time-varying responses of housing starts and real GDP relative to real house prices to an expansionary monetary policy shock. Responses for 12 and 36 months after the shock. The grey bars represent US recessions as defined by the NBER.

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2. Alternative measure of real activity: non-farm payrolls

Figure 6: Time-varying impulse response functions

Real house prices
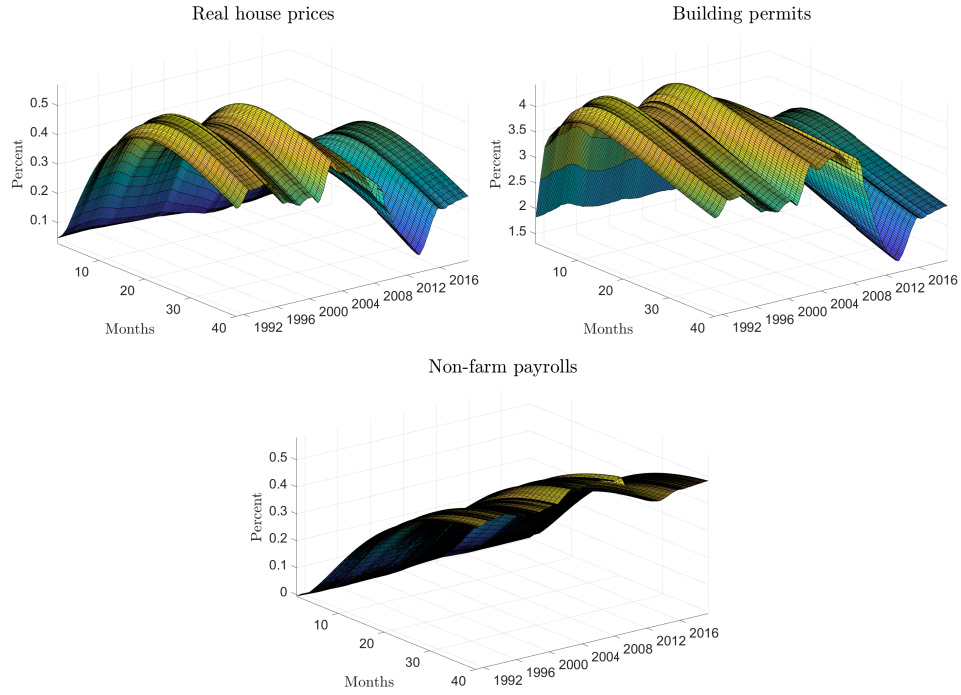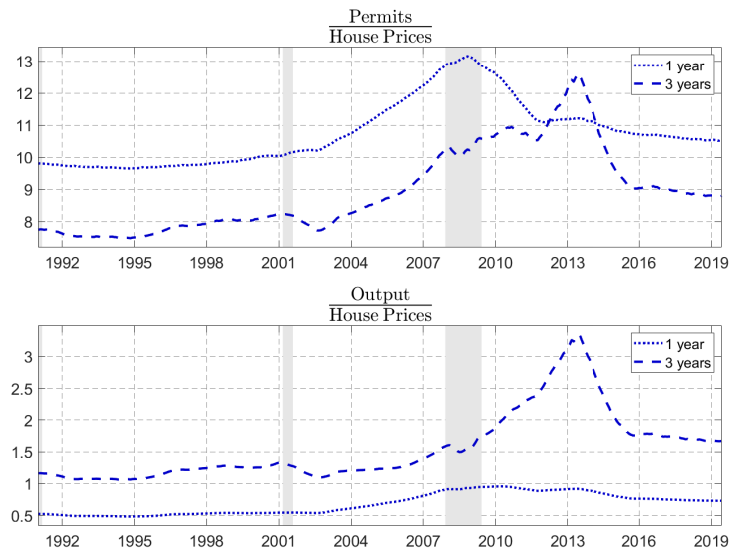
Building permits

Non-farm payrolls

Figure 7: Relative impulse response functions

3. Alternative measure of real activity: unemployment rate

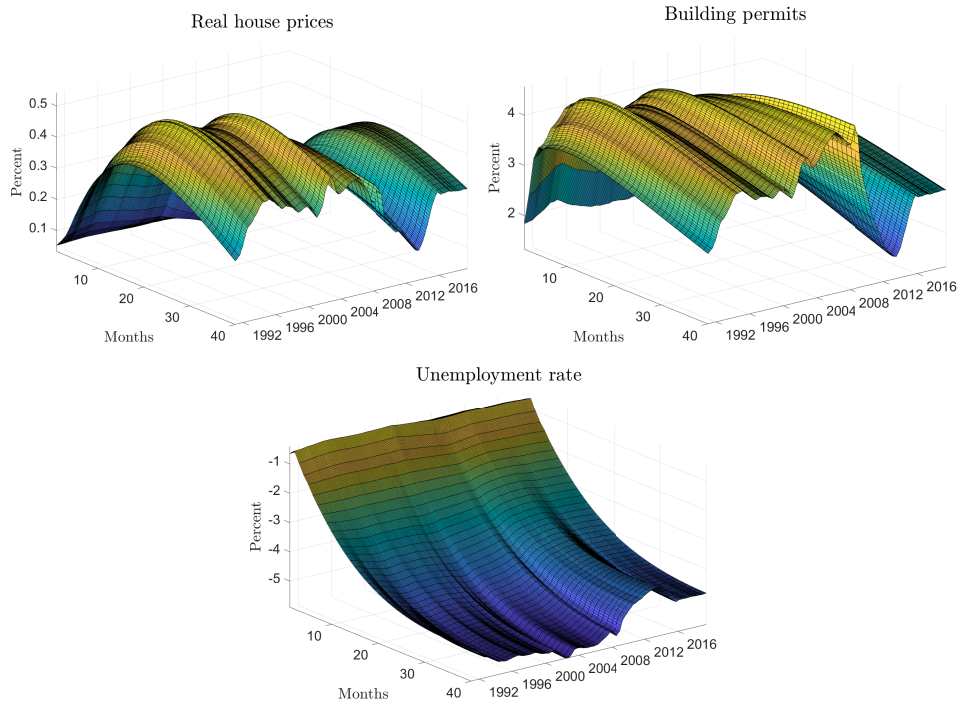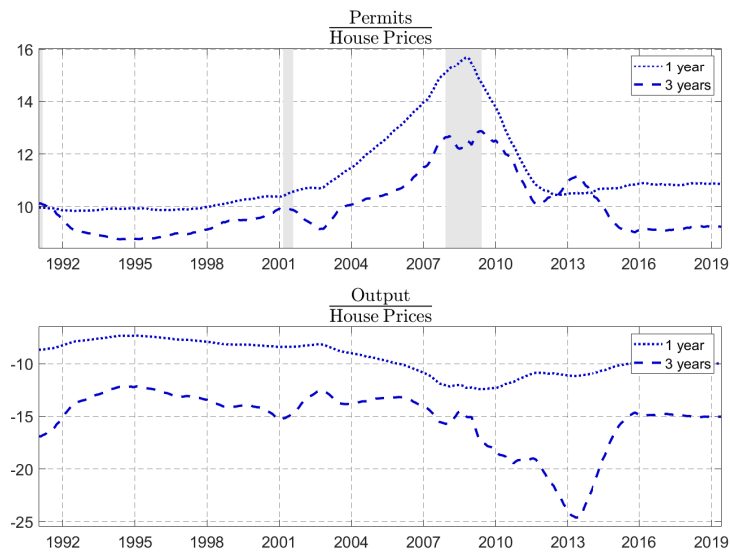### Figure 8: Time-varying impulse response functions

Real house prices

Building permits

Unemployment rate

Figure 9: Relative impulse response functions

4. Alternative policy rate: Federal funds rate
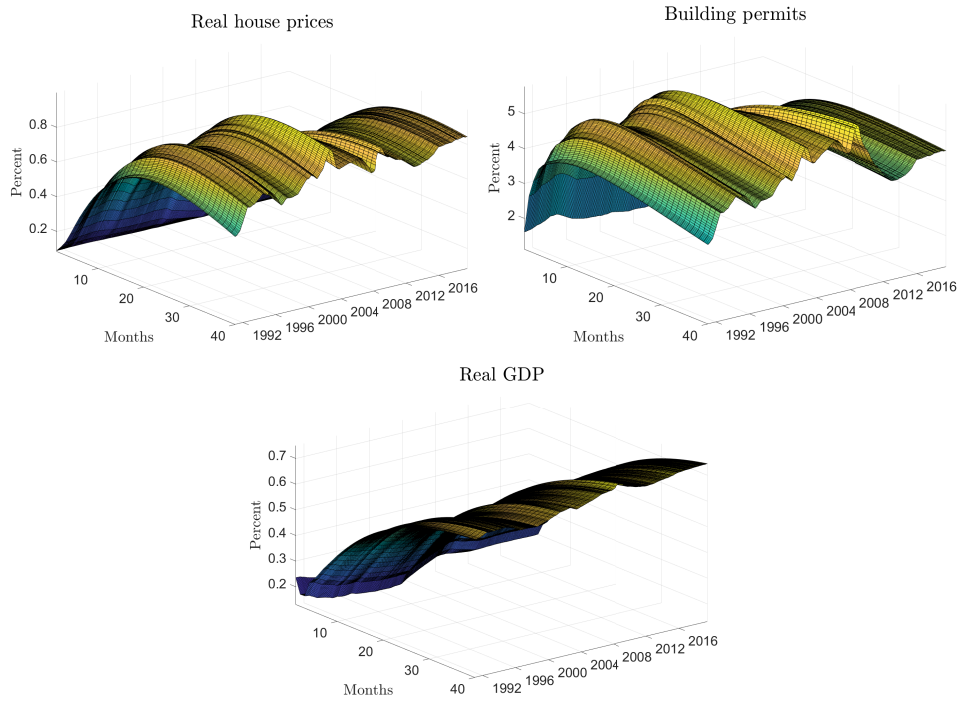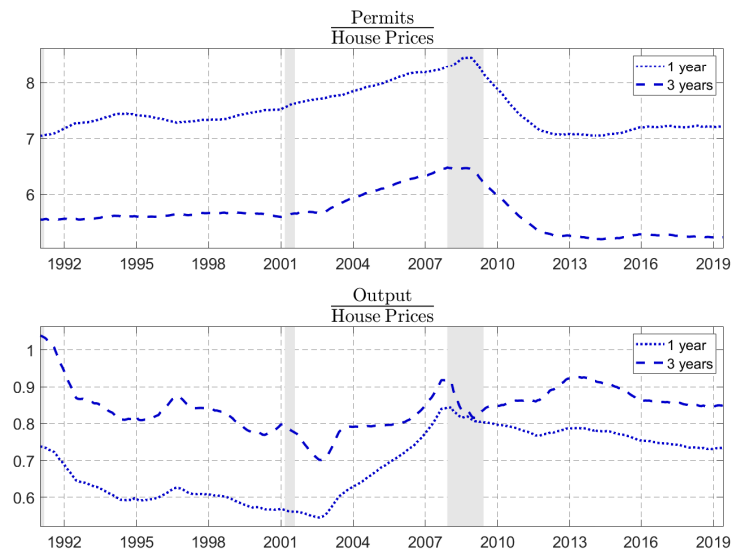
Figure 10: Time-varying impulse response functions

Real house prices

Building permits

Real GDP

Figure 11: Relative impulse response functions

5. Alternative policy rate: two-year Treasury rate

Figure 12: Time-varying impulse response functions
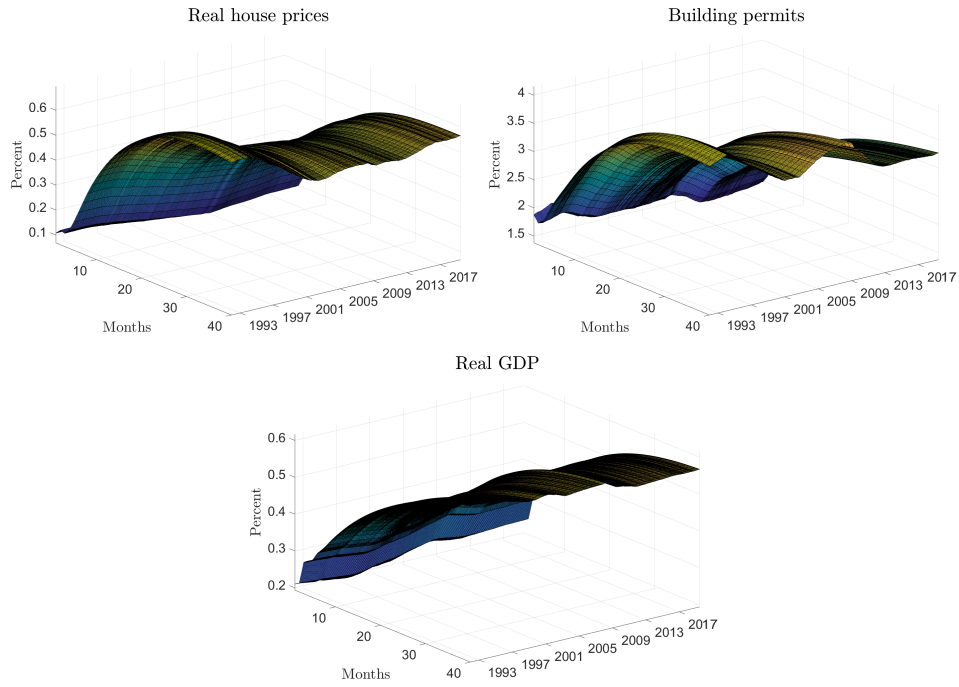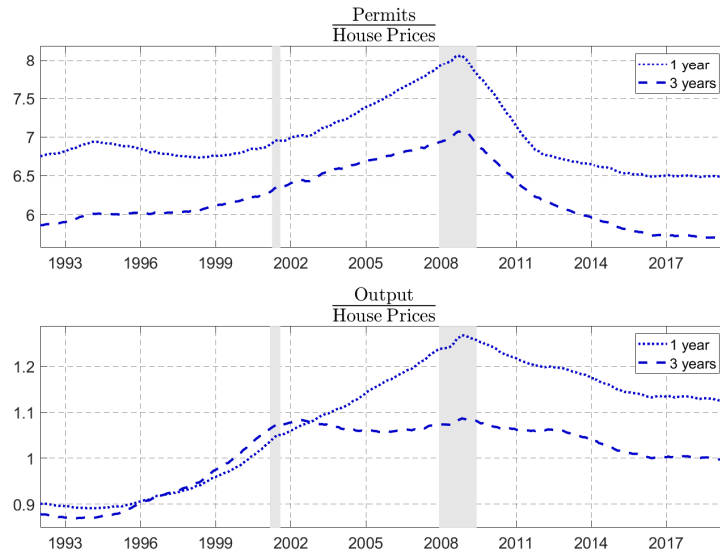
Real house prices

Building permits

Real GDP

Figure 13: Relative impulse response functions

6. Lag length: VAR(2)

Figure 14: Time-varying impulse response functions

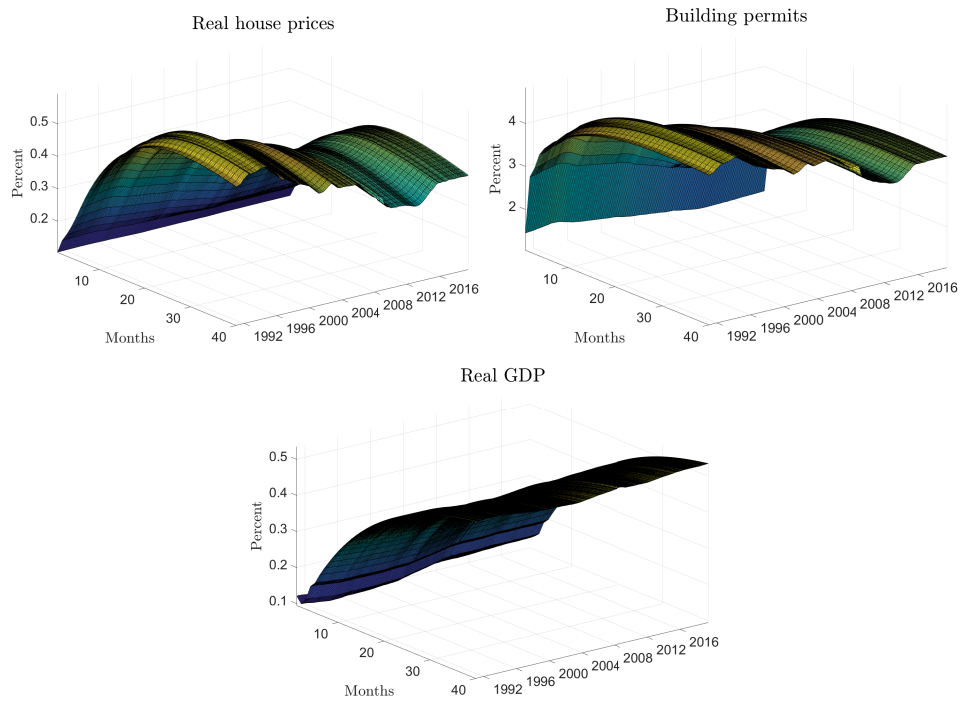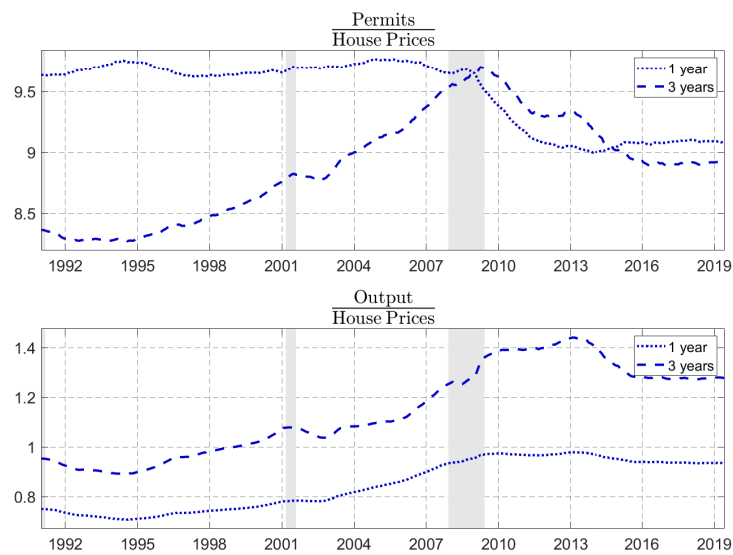Real house prices

Building permits

Real GDP

Figure 15: Relative impulse response functions

7. Alternative surprise series: full yield spectrum from Bu et al. (2019)

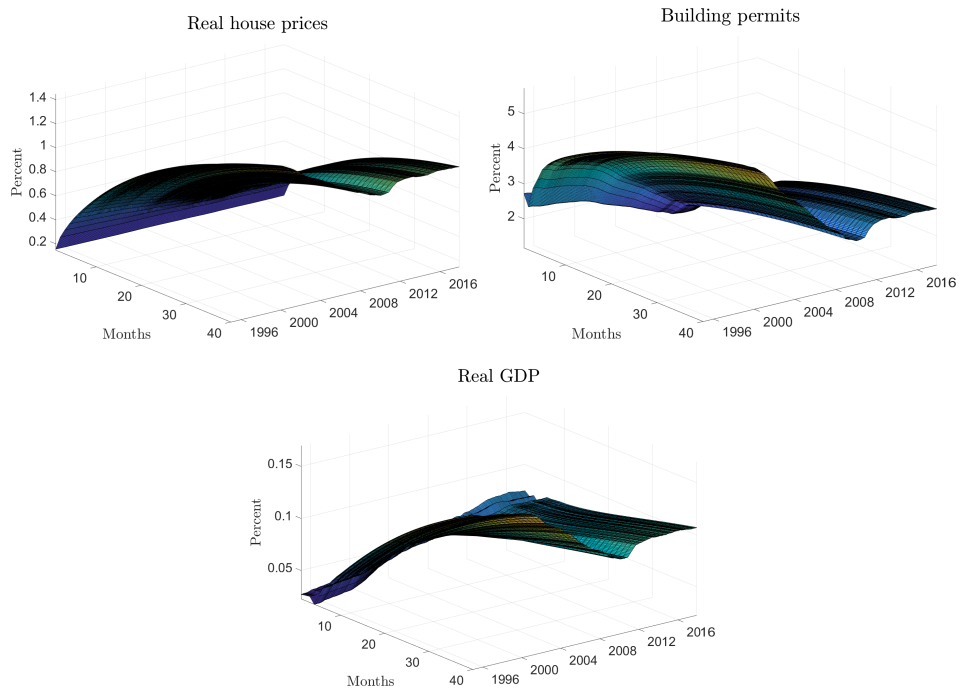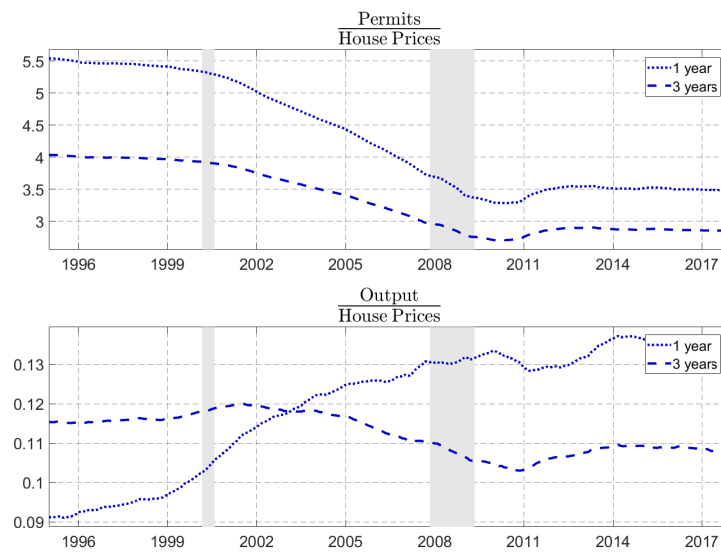Figure 16: Time-varying impulse response functions

Figure 17: Relative impulse response functions

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Gilchrist, S. and Zakrajšek, E. (2012). Credit Spreads and Business Cycle Fluctuations. *American Economic Review*, 102(4):1692–1720.

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